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**PSC Overview Series . . .**

# Renewable Energy Resources


**Public Service Commission of Wisconsin**

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This overview contains information that will be useful to people who have an interest in the role of renewable energy resources in Wisconsin's electrical generation mix.





To obtain any of these Overviews, contact the Public Service Commission, by phone (608) 261-8524 or e-mail *pscrecs@psc.state.wi.us*, or check our home page at: http://www.psc.state.wi.us.

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- EMF -Electric and Magnetic Fields
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- Merchant Plants and Other Non-Utility Generation
- Nuclear Power Plant Decommissioning and Radioactive Waste Disposal
- Right-of-Way and Easements in Electric Facility Construction
- Underground Electric Transmission Lines





## Renewable Energy



"Renewable energy" refers to energy that is continuously replenished by natural processes. The resources with the greatest interest for electrical generation in Wisconsin are:

- Hydroelectric—using falling water to turn a generator.
- Wind—using the moving air to turn a generator.
- Biomass—burning plant material, from farm and forest crops or from waste, in a conventional thermal power plant. Biomass can also be made into alcohol or methane gas.
- Solar—using the photovoltaic effect to convert photons from the sun directly into electricity. The sun's heat can also be used directly to produce heat and light, displacing the need for electricity.

## Advantages and Disadvantages of Renewable Resources

The advantages of renewable resources include:

- Low or no fuel cost (except for some biomass);
- Short lead-times for planning and construction;
- Relatively small, modular plant sizes;
- Reduced environmental effects compared to fossil fuels;
- Non-depletable resource base;
- Potentially more job intensive;
- Favorable public opinion; and
- Distributed generation potential.

The disadvantages include:

- Relatively high capital cost;
- Lack of utility comfort with some technologies;
- Uneven geographic distribution;
- Intermittent availability of some resources;
- Lack of maturity or commercial availability of technologies;
- Public concern for land use, biodiversity, birds, and aesthetics; and
- Environmental issues with fuel supply (biomass and waste-to-energy).

Utilities and independent power producers are researching ways to expand the use of renewable resources. The two most important benefits of renewable resources are their long-term availability and, because they don't produce acid rain and have not been associated with global climate change, minimal atmospheric impact.

As of 1994, Wisconsin state law mandates that, "It is the goal of the state that, to the extent that is cost-effective and technically feasible, all new installed capacity for electric generation in the state be based on renewable energy resources, including hydroelectric, wood, wind, solar, refuse, agricultural and biomass energy resources."

Section 27 of 1997 Wisconsin Act 204 (Act 204) required the eastern Wisconsin utilities to build 50 MW of renewable resources prior to 2001. In October 1999, Reliability 2000 (R2K) was passed. This legislation establishes a Renewable Portfolio Standard for Wisconsin, which phases in over 10 years and requires that any utility providing retail electricity provide 2.2 percent of its energy from renewable resource by December 31, 2011.





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In construction cases, for both transmission and generating facilities, the PSC and state law require utilities to consider use of renewable resources to either reduce or eliminate the need for the new facility. PSC staff is currently working to determine to what extent generation from renewable resources can delay the need to upgrade specific power lines.

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## Wind energy

### Electric power from the wind

Wind energy is converted to electricity when wind passes by blades designed like those of an airplane propeller mounted on a rotating shaft. As the wind moves the blades, the rotation of the shaft turns a generator which produces electricity.

Three factors affect wind machine power. The length and design of the blades, the density of the air, and wind velocity. Blades are shaped and positioned to take advantage of different wind velocities so that, depending on design, one wind machine may produce power in a different range of wind velocities than another. Power output is directly proportional to the length of the blades.

Cold air is denser, which means it has more force, or ability to turn the blades. A wind machine in Wisconsin's cold, dense winter air can produce up to 20 percent more than the same machine with the same wind speed but warmer air.

Since output is proportional to the cube of the wind velocity,[1] the speed of the wind is critical for the cost-effective operation of wind machines. Generally, the higher a wind turbine is mounted, the more wind it will encounter.

[1] $P=\frac{1}{2}DAV^3$ (P=power produced; D=air density; A=swept area of the turbine blades; and V=the velocity of the wind in miles per hour).

Working with PSC staff and other interested parties, Wisconsin

electric utilities have established a comprehensive statewide wind resource assessment program (WRAP). This program was ordered by the PSC to encourage wind power development in those areas of the state with the best wind energy potential. For a 3-year period, wind speed and direction will be recorded at 13 sites and at 10, 25, 40, and 60 meter elevations. The information from WRAP is available to the public through the Wisconsin Energy Bureau [phone (608) 266-7043 or e-mail jeffrey.carlson@doa.state.wi.us].

The eastern Wisconsin utilities working with the Electric Power Research Institute (EPRI), a national research organization, are operating two 600 kW wind machines to gain experience with the technology.

There are currently four utility-scale wind farms in Wisconsin:

- 11.22 MW project by Madison Gas and Electric Company
- 9.24 MW project by Wisconsin Public Service Corporation
- 2—600 KW wind power facilities at Glenmore
- 2—660 KW wind power facilities near Byron in southeast Wisconsin

### Environmental issues associated with wind energy

Wind energy can have both positive and negative impacts on the environment. One of the major benefits of this technology is that it does not create air pollution. Power plants that burn coal, for example, emit sulfur dioxide ($SO_2$), nitrogen oxides (NOx), carbon dioxide ($CO_2$), particulates, and heavy metals into the atmosphere. Gas-fired power plants emit NOx and $CO_2$. Emissions from power plants contribute to acid rain which has been shown to damage lakes, streams, and forests.





some that is not, depending on the type of materials recycled. In the process of doing this, waste combustion for energy becomes less economical.

Many factors affect the waste-to-energy issue. The final decision of whether or not it is appropriate, feasible, and economical should be made on a case-by-case basis. Utilities have been using certain specific wastes as fuels along with coal. Examples include paper mill sludge and tire-derived fuels. Methane gas generated at landfills and wastewater treatment plants must be burned. Electricity could be produced as a by-product of burning the gas.

## Regulation and the use of renewable resources

The federal and state governments can have significant influence on the attractiveness of renewable resources by providing tax advantages for owners of renewable systems. National and state pollution standards, which increase the costs of conventional generation, are another factor influencing the economics of systems powered by renewable resources. Research and development funded by the federal government and private enterprise can also improve the cost effectiveness of renewable systems.

## PSC Role

The PSC will be examining potential policy actions that could improve opportunities for generating electricity with renewable resources. These potential actions could include, among others, fostering the creation of “green pricing” programs or requiring renewable portfolio standards for electricity suppliers. Utilities are encouraged to consider other environmental benefits as they examine renewable energy sources.

Table 1 compares some biomass fuel types with western low-sulfur coal. All of the listed biomass types are available in Wisconsin, but the amount of generation that could be supported by each is unknown.

## Waste-to-Energy

The waste-to-energy solution addresses two problems. It reduces waste volume by burning the material and it recovers the resulting energy by converting it to electricity. Two types of waste products have potential as fuels. They are:

- Landfill gas
- Wastewater treatment plant gas

For many years land filling was the preferred way to manage municipal solid waste. However, environmental concerns have made it increasingly difficult to site landfills.

Recently enacted state law restricts the burning and landfilling of solid waste in favor of reusing, recycling, and composting. Wisconsin law establishes the following hierarchy for solid waste management:

- Reduction at the source
- Reuse
- Recycling
- Composting
- Waste combustion with energy recovery
- Land disposal
- Waste combustion without energy recovery

Source reduction and reuse involve limiting wastes at their source and are the preferred methods of reducing the volume of solid waste. Recycling reduces the amount of solid waste that requires disposal, removing some waste that is burnable and





Power plant emissions also contribute to ozone formation which can affect human health. Emissions of $CO_2$ have been linked to global warming.

Because wind generated electricity does not use water, potential negative impacts such as thermal pollution of water bodies is avoided. Wind energy also avoids impacts related to water use such as depletion of ground water supply and impacts to the supply and flow of surface waters. Wind energy does not create solid waste, so transportation, treatment, and storage of wastes are also avoided.

From a social and economic standpoint, wind power has several advantages. Wind energy generally requires a larger workforce than typical combustion technologies. A 1992 study by the New York State Energy Office showed that on a watt for watt basis, wind power creates 66 percent more jobs than natural gas-fired generation and 27 percent more jobs than coal-fired electricity generation. From an economic standpoint, wind power does not have any associated fuel-price risks. Because wind power requires no fuel, the cost of wind generated electricity would not be affected by volatility in fuel prices.

### Environmental concerns for wind energy

The risk of avian mortality is one of the major environmental concerns associated with wind energy. Bird collisions with turbine blades and towers have been reported in this country and in Europe. Hawks, falcons, and eagles are commonly mentioned in the scientific literature as being susceptible to mortality from collision with wind turbines. However, smaller birds and bats may also be at risk. This issue has become rather controversial and is the subject of increasing study. Avian impacts associated with wind turbines are currently being studied in California, Wyoming, Spain, the Netherlands, England, and Scandinavia. Studies are also being conducted in Minnesota and Wisconsin.

Impacts to birds and bats can be reduced with careful siting of facilities. The PSC, in cooperation with electric utilities, other state and federal agencies, and environmental groups, is developing wind energy siting guidelines using Geographic Information System (GIS) technology. The siting guidelines and information resources developed from this project will identify areas where there are biological concerns in Wisconsin and combine this information with wind speed data from the on-going Wind Resource Assessment Program. This information will then be used as a guide for achieving environmentally sensitive siting of wind energy facilities.

Other issues often associated with wind energy include concerns about noise and negative impacts to property values. Noise problems associated with wind turbine facilities are currently being studied in northeastern Wisconsin. Potential effects on property values are difficult to isolate. Market prices for rural and residential property normally change over time, subject to a variety of variables. Factors affecting property values including the general condition of the local and national economy, taxes, the reputation of the school system, and the availability and condition of infrastructure (i.e. Roads, police and fire protection). It is impossible, at this time, to predict the impact to property values from the presence of wind turbines.

## Solar energy

### Solar heating

Sunlight can be used to provide energy in three ways. One way is to convert the sunlight into heat using a solar collector. The heat can be used for space heating, water heating, or for certain manufacturing processes. When solar energy replaces electricity in these applications, it can





3. Woody or herbaceous energy crops—grown sustainably on cropland or in plantations and dedicated to be converted to electricity. Crops showing the most promise in Wisconsin include hybrid poplars, willows, and switchgrass.

4. Natural woodlands—harvesting trees for fuel. This option is by far the least preferable and most complicated environmentally.

The environmental effects of obtaining these fuels vary. All would require truck or rail transportation. Storage emissions and other effects might be a concern. At this time, however, it is early enough in the development of biomass technologies in Wisconsin to investigate storage options and sustainable plantations using landscape-level ecological planning. Adaptive resource management can research questions about environmental impacts while biomass technologies continue to progress.

**Table 1 Wood supply compared to coal supply**

| Fuel Source | $ per Mbtu | Environmental Imact of Supply |
|---|---|---|
| Primary mill | 0.82 to 1.18 | Reduces landfilling |
| Industrial | 0.84 | Reduces landfilling |
| Harvesting residues | 1.53 to 1.76 | Impacts on soil stru cture and fertility can be minimized by leaving appropriate amounts of residue behind. |
| Plantation | 2.46 to 4.24 | Impacts on soil, water, and wildlife can be reduced by best management practices for cropping and harvest. |
| Forest harvest | 1.53 to ? | Many potential impacts of cost increases related to harvesting directly from forest. |
| Low-sulfur western coal | <1.0 | Must be imported to state. Mining impacts elsewhere but greater than any of the above |

Waste wood is burned today in several generating plants in Wisconsin, including a few utility-owned plants, to produce steam for both electric energy and industrial processes. (This dual use of the steam is know as "cogeneration.") In some cases, the wood is burned along with coal, to reduce coal emissions, in a process known as "co-firing."

Co-firing with coal appears to be the most available biomass technology today, but co-firing potential is different for each coal plant. Different types of plants handle and burn their coal in different ways. Conversion of a coal plant to co-firing with biomass requires changes to that plant's boiler and its fuel handling process. A reliable supply of biomass fuel also must be guaranteed.

Other biomass technologies exist. There are power plants that burn chipped wood alone or that co-fire the chips with natural gas. Two major technologies might be ready early in the next century. One would convert the biomass to a gas to burn. The other would harvest and burn the whole above-ground portion of the tree at once. All of these technologies require guaranteed biomass fuel supplies. The supply for facilities burning only biomass would need to be much greater than the supply needed for co-firing.

The PSC has determined that potential fuel supplies for environmentally sound biomass-fired power plants should be used in the following priority order:

1. Wood industry residues—e.g., lumber mill residues and sawdust, furniture manufacturing wastes, pallets, etc.

2. Urban, forest, or agricultural residues—residues resulting from logging cropping, or city tree trimming. Enough logging or cropping residue must be left on the ground to ensure stable soil conditions and appropriate plant nutrient cycling.





reduce the need for generating capacity. Solar water heaters have been commercially available for many years and thousands have been installed in Wisconsin. Much of this development was promoted by tax credits which are no longer available. The use of solar energy for space heating using "passive" methods has also been popular.

## Photovoltaics (PV)

Another way to use solar energy is by converting sunlight directly into electricity through the use of photovoltaic cells, which are grouped together to form a panel. Photovoltaic panels can be used in small groups on rooftops or as part of a substantial system for producing large amounts of electrical power. The amount of energy produced by a photovoltaic system depends upon the amount of sunlight available. The intensity of sunlight varies by season of the year, time of day, and the degree of cloudiness. Currently, PV generated power is less expensive than conventional power technologies where the load is small or the area is too difficult to serve by electric utilities. Recent breakthroughs may reduce the cost of producing electricity with photovoltaic systems to 10 to 12 cents per kilowatt hour (kWh) or lower. This compares to 3 cents per kWh for fossil generated power.

While further advances in solar technology are likely, some technologies are available today. As a result of private and government research, photovoltaic systems are becoming more efficient and affordable. Utilities also fund research in these same areas through membership in EPRI. With continued improvement, it is likely that photovoltaic technologies will become increasingly cost competitive with conventional generation sources.

Compared to traditional methods of electric generation, photovoltaic systems have few environmental concerns. The primary environmental impacts of large ground arrays is visual and can be solved by designing them to blend with their surroundings.

### Daylighting

The third way to use the sun is to provide daylighting through appropriate design in residential, commercial, and industrial buildings. The use of natural light reduces energy in two ways. Not only is less energy used for lighting, but the need for summer air conditioning is also reduced since there is less heat generated by electric lights.

## Hydroelectricity

The energy from moving water is converted to electricity when water passes by blades similar to those on a ship's propeller. The blades are connected to a rotating shaft which turns a generator to produce electricity. Dams are used to control the flow of water.

Although some potential exists for additional hydroelectric development in Wisconsin, public, environmental, and recreational concerns limit the potential for new hydro installations. Current development is centered around refurbishing existing dams and generating equipment. As of 1998, Wisconsin has 535 MW of hydroelectric capacity.

Relicensing existing dams is a significant concern at this time. The Federal Energy Regulatory Commission grants licenses to dam operators for periods of up to 50 years. When a dam is scheduled to be relicensed, environmental concerns are re-





examined. Dam operation may be restricted to meet new regulations. These operating restrictions may reduce the amount of energy produced, which may require an increased use of fossil fuels and a corresponding increase in air pollution.

The Wisconsin utilities have identified sites for possible hydroelectric development. Most of these sites involve installing electric generators at existing dams. Private developers also have access to this information.

Hydroelectric plants do not contribute to air pollution concerns such as the greenhouse effect and acid rain. However, changes in dam operating procedures may alter river habitat.

## Biomass energy

Biomass energy is the energy in recently grown plant materials, as opposed to plant materials that have been fossilized as coal or natural gas. Biomass can be burned like coal to produce steam. It might also be gasified and burned like natural gas. Biomass can include waste wood from construction or demolition projects or from wood product manufacturing. It can also include energy crops. Waste wood is the most available source of biomass in Wisconsin today.

Air emissions from biomass combustion are less than those from coal or natural gas. Like coal or natural gas combustion, biomass combustion produces $CO_2$, an important greenhouse gas. Growing plants to replace the burned plant material creates a "closed loop" for $CO_2$ and avoids increasing the overall amount of $CO_2$ in the air. Biomass can also emit lower amounts of NOx and less ash than coal, as well as significantly less toxic elements such as mercury.